

This listing of the claims will replace all prior versions.

LISTING OF CLAIMS:

Claim 1 (withdrawn). A method for generating hydrogen, comprising:

- providing a hydrogen reactor chamber;
- providing a plurality of catalysts within said hydrogen chamber to form a staged catalyst medium, the staged catalyst medium comprising a series of distinct zones or portions, each zone or portion comprising a distinct catalyst or combination thereof having a unique definitive characteristics; and
- passing a feed stream of hydrocarbons through the staged catalyst medium to produce hydrogen.

Claim 2 (withdrawn). The method of claim 1, wherein said plurality of catalysts is comprised of at least one of a high-activity steam reformation catalyst and a coke-resistant steam reformation catalyst.

Claim 3 (withdrawn). The method of claim 2, wherein said plurality of catalysts is further comprised of a steam reformation catalyst that promotes a water-gas shift reaction.

Claim 4 (withdrawn). The method of claim 1, further comprising introducing said feed stream of hydrocarbons into said hydrogen reactor chamber.

Claim 5 (withdrawn). The method of claim 1, wherein said feed stream of hydrocarbons is a fuel having at least one of a C₁-C₄ hydrocarbon or mixture, or a C₁-C₄ oxygenate thereof.

Claim 6 (withdrawn). The method of claim 1, wherein at least 300 sccm of hydrogen or reformed gas stream is produced in conjunction with residence times of less than about 0.5 sec.

Claim 7 (withdrawn). The method of claim 4, wherein said at least one hydrocarbon is propane and provides hydrogen production at residence times of about 0.15 to about 0.30 sec and at a temperature of about 575° C.

Claim 8 (withdrawn). The method of claim 1, wherein providing a plurality of catalysts within the reactor chamber can be performed by loading said plurality of catalysts within said hydrogen reactor chamber such that said feed stream of hydrocarbons is exposed to said plurality of catalysts in a predetermined sequential manner.

Claim 9 (withdrawn). The method of claim 8, further comprising introducing said feed stream of hydrocarbons to a steam reformation catalyst, the reformation catalysts also promoting the water-gas shift reaction, the reformation catalyst located adjacent entrance or exit portions of said hydrogen reactor chamber.

Claim 10 (withdrawn). The method of claim 1, wherein providing a plurality of catalysts within the reactor chamber can be performed by loading said plurality of catalysts within said hydrogen reactor chamber such that said staged catalyst medium includes a first portion having a steam reformation catalyst, which also promotes the water-gas shift reaction, located adjacent entrance or exit portions and a second portion including at least one of a high-activity steam reformation catalyst and a coke-resistant steam reformation catalyst.

Claim 11 (withdrawn). The method of claim 2, wherein providing a plurality of catalysts within the reactor chamber can be performed such that the high reforming and water gas shift activity characteristics of at least one catalyst is balanced with resistance to coking.

Claim 12 (withdrawn). The method of claim 11 wherein said coke-resistant catalyst is loaded at an entrance of the hydrogen reactor chamber, followed by said high-activity catalyst or wherein all or part of the coke-resistant catalyst is mixed with said high-activity catalyst, before loading into the hydrogen reactor chamber.

Claim 13 (withdrawn). The method of claim 1, further comprising the step of hot swapping of fuels in the C₁-C₄ range to obtain fuel flexibility and uninterrupted production of hydrogen or a reformed gas stream.

Claim 14 (withdrawn). A hydrogen generation apparatus comprising a reactor chamber wherein a hydrogen generating reaction is performed, the reactor chamber comprising a plurality of catalysts in a staged configuration, wherein the plurality of staged catalysts is provided to form a staged catalyst medium.

Claim 15 (currently amended). A hydrogen generating apparatus wherein hydrogen is generated by steam reformation of a hydrocarbon fuel, the apparatus comprising a single hydrogen reactor chamber in which is disposed a plurality of steam reformation catalysts to form a staged configuration, the staged configuration comprising a series of zones or portions, each zone or portion in physical contact with at least one other zone or portion and each zone or portion containing at least one of a plurality of steam reformation catalysts;

wherein said apparatus comprises a channeled insert;

wherein a feed stream passed in the reactor chamber is passed through the zones or portions and is exposed to the plurality of catalysts in a predetermined sequential manner, and

wherein said plurality of steam reformation catalysts includes a high-activity steam reformation catalyst, a coke-resistant steam reformation catalyst and a steam reformation catalyst which promotes a water-gas shift reaction.

Claim 16 (cancelled).

Claim 17 (previously presented). The hydrogen generating apparatus of claim 15, wherein the coke-resistant steam reformation catalyst is loaded at an entrance of said hydrogen reactor chamber.

Claim 18 (cancelled).

Claim 19 (previously presented). The hydrogen generating apparatus of claim 15, wherein said high-activity steam reformation catalyst is a supported by nickel-based catalyst.

Claim 20 (previously presented). The hydrogen generating apparatus of claim 15 wherein said coke-resistant steam reformation catalyst is a supported doped nickel-based catalysts.

Claim 21 (original). The hydrogen generating apparatus of claim 20, wherein said supported doped nickel-based catalyst is comprised of at least one of calcium oxide, potassium oxide and calcium aluminate or combinations thereof.

Claim 22 (original). The hydrogen generating apparatus of claim 21, wherein said supported doped nickel-based catalysts is further comprised of at least one noble metal.

Claim 23 (original). The hydrogen generating apparatus of claim 22, wherein said at least one noble metal is at least one of platinum, palladium, rhodium, or ruthenium or any combination thereof.

Claim 24 (currently amended). The hydrogen generating apparatus of claim 15, wherein said coke-resistant steam reformation catalyst is loaded at an entrance of said steam reformer, followed by said high-activity steam reformation catalyst.

Claim 25 (previously presented). The hydrogen generating apparatus of claim 15, wherein the high activity steam reformation catalyst contains at least one noble metal component.

Claim 26 (original). The hydrogen generating apparatus of claim 15, wherein the plurality of catalysts are powders or coatings supported on a substrate.

Claim 27 (original). The hydrogen generating apparatus of claim 26, wherein said substrate is selected from the group consisting of foams, monoliths, felts and mesh, or any combination thereof.

Claim 28 (previously presented). The hydrogen generating apparatus of claim 15, wherein a fuel cell is in fluid communication with the hydrogen generating reactor.

Claim 29 (withdrawn). A method for generating hydrogen by steam reformation of a hydrocarbon fuel, the method comprising:

providing a steam reformer; providing a plurality of catalysts within the steam reformer to form a staged catalyst medium; and

passing a hydrocarbon fuel feed stream in the steam reformer to obtain a hydrogen containing reformed stream, the reformed stream is purified to product hydrogen.

Claim 30 (withdrawn). A method for manufacturing a hydrogen generation apparatus, the method comprising:

providing an element of the apparatus wherein a reaction associated with hydrogen production is performed; and

providing within said element a plurality of catalysts in a staged catalyst medium, the staged catalyst medium comprising a series of distinct zones or portions, each zone or portion comprising a distinct catalyst or combination thereof.

Claim 31 (withdrawn). The method of claim 29, wherein purification of the reformer stream is achieved using a hydrogen separation membrane.

Claim 32 (currently amended). A hydrogen generating apparatus wherein hydrogen is generated by steam reformation of a hydrocarbon fuel through staged catalysis, the apparatus comprising

a hydrogen reactor chamber containing steam reformation catalysts, the catalysts in zones or portions and each zone or portion in physical contact with at least one other zone or portion;

wherein said apparatus comprises a channeled insert:

wherein a feed stream passed in the reactor chamber is passed through the zones or portions and is exposed to each of the catalysts, in series, in a predetermined sequential manner; and,

each physically contacted zone or portion containing at a different steam reformation catalysts;

wherein said different steam reformation catalysts includes a high-activity steam reformation catalyst, a coke-resistant reformation catalyst and a steam reformation catalyst which promotes a water-gas shift reaction.

Claim 33 (previously presented). The hydrogen generating apparatus of claim 32, wherein the end of each zone or portion is in contact with another zone or portion is an abrupt end.

Claim 34 (previously presented). The hydrogen generating apparatus of claim 32, wherein the end of each zone or portion is in contact with another zone or portion is characterized by a decreasing gradient of one or more catalysts and an increasing gradient of another.

Claim 35 (presently presented). The hydrogen generating apparatus of claim 32, wherein the end of each zone or portion is in contact with another zone or portion is characterized by at least one of a decreasing gradient of one or more catalysts and an increasing gradient of another and an abrupt end.

Claim 36 (new). A hydrogen generating apparatus wherein hydrogen is generated by steam reformation of a hydrocarbon fuel, the apparatus comprising

a single hydrogen reactor chamber in which is disposed a plurality of steam reformation catalysts to form a staged configuration, the staged configuration comprising a series of zones or portions, each zone or portion in physical contact with at least one other zone or portion and each zone or portion containing at least one of a plurality of steam reformation catalysts;

wherein said apparatus comprises a channeled insert;

wherein a feed stream passed in the reactor chamber is passed through the zones or portions and is exposed to the plurality of catalysts in a predetermined sequential manner, wherein the series of zones or portions comprises a first zone and a second zone in series, wherein an inlet introduces the feed stream to the first zone, wherein an outlet removes feed stream from the second zone, and wherein all of the feed stream that passes through the first zone must also pass through the second zone before passing through the outlet, and

wherein said plurality of steam reformation catalysts includes a high-activity steam reformation catalyst, a coke-resistant steam reformation catalyst and a steam reformation catalyst which promotes a water-gas shift reaction.

Claim 37 (new). The hydrogen generating apparatus of Claim 36, wherein the series of zones or portions comprises a first zone, a second zone, and a third zone, in series, wherein an inlet introduces the feed stream to the first zone, wherein an outlet removes feed stream from the third zone, and wherein all of the feed stream that passes through the first zone must also pass through the second zone before passing through the outlet, and wherein all of the feed stream passing through the first zone must also pass through the third zone before passing through the outlet.